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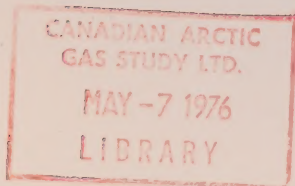
PROGRESS REPORT
1975
TUNDRA REHABILITATION RESEARCH
PRUDHOE BAY AND
PALMER RESEARCH CENTER

to

Alyeska Pipeline Service Company
Atlantic Richfield Company
Canadian Arctic Gas Study Limited
Exxon Company
Shell Oil Company
Union Oil Company

by the

University of Alaska
Agricultural Experiment Station
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W. W. Mitchell

J. D. McKendrick

T. E. Loynachan



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INTRODUCTION

Following is a summary report of activities on the tundra rehabilitation project. Many of the details will be included in later reports.

Further progress was made in 1975 in determining the adaptability of particular plant selections for revegetation work in the Arctic, but planting failures also emphasized some of the limitations to successful seedings under these conditions. Nutrient relationships between soil and plant were elucidated in both field and laboratory work on Prudhoe Bay soils. Observations were continued on the course of natural rehabilitation on disturbances in the Prudhoe Bay area. Selections of suitable genetic material within species showing adaptation to the Arctic was furthered, and development of basic seed stocks of some of these materials was advanced to a considerable extent. A great deal of effort has been put into this program at Palmer.

SPECIES TRIALS, SELECTIONS, AND SEED INCREASE

Out of 68 separate entries in 20 species planted in broadcast plots in 1972 at Prudhoe Bay, 16 entries in 6 species maintained an average of 50% or more coverage (for 3 replications) in 1975. Nine others averaged between 25% and 50% coverage. All but one of these entries were experimental selections of native plants collected in Alaska. The one other successful entry was the variety Arctared fescue, developed from material found growing on Alaska Experiment Station property. (The variety behaves like native Alaskan material and possibly could be of this origin.) Thirty-nine entries essentially failed. Six of 41 entries in row plantings

established in 1972 maintained over 45% coverage through the 1975 season. Five of these were native Alaskan collections and one was an Iceland entry.

Nineteen commercial varieties from north temperate and boreal regions were tested and only the one variety of red fescue developed in Alaska has proved consistently successful. An Alaskan-developed variety of Kentucky bluegrass, Nugget bluegrass, has had some qualified success.

Plantings conducted subsequent to 1972 have served to test the consistency of performance of the more promising materials and to help differentiate between selections being made for possible use. These trials also have stressed the need for planting procedures that accommodate for the limiting factors of low temperature in company with low moisture conditions that obtain on well drained arctic sites.

The trials have delineated the following species in which plant materials have been found promising or suitable for use in the Arctic:

Arctagrostis latifolia

Calamagrostis canadensis

Deschampsia caespitosa-beringensis complex

Festuca rubra

Poa glauca

Puccinellia sp.

Arctagrostis latifolia - As a result of this project and other work conducted along the pipeline route a variety of Arctagrostis latifolia has been developed consisting of a composite of biotypes collected from a number of locations in interior and western Alaska. Fifteen acres have been planted to this variety for commercial seed production, and the first seed was harvested in 1975. Though widespread in the Arctic, no arctic materials of this species have proved satisfactory for use because of

poor seed-producing qualities and poor adaptation to conditions where the grass would have to be grown for seed. Under favorable conditions the grass is lush growing with relatively broad leaves and appears highly desired by caribou.

Calamagrostis canadensis - A composite variety of Calamagrostis canadensis (bluejoint reedgrass) has been developed of collections from interior, western, and southcentral Alaska. This material also has been planted for commercial seed production, and the first harvest will be conducted in 1976. As with the Arctagrostis, no arctic materials of this grass are included in the variety. The species is rare in occurrence in the Arctic and no satisfactory material has been found as yet. Bluejoint is a leafy, tall growing grass found abundantly through interior to southern Alaska.

Deschampsia caespitosa-beringensis complex - Work in 1975 further delineated those selections under study in the Deschampsia caespitosa-beringensis complex (hairgrass) best adapted for arctic use. Some shifts in emphasis among collections under study have been necessitated by results obtained in the last 2 years. Entries of subarctic and boreal origin are currently being considered for varietal status. Seed increase is under way of these selections. Arctic materials of this grass are being studied at Palmer, and though they have done well vegetatively, none have performed adequately for seed production purposes. Further collections of arctic seed have been made, and work is continuing on arctic material of this grass. In the meantime, additional tests were established in 1975 at Prudhoe Bay of entries that have emerged from previous trials with the best potential for use. Selections also are being made of individuals

among these entries for superior performance at Palmer. Hairgrass is a medium to tall growing bunchgrass.

Festuca rubra - Arctared red fescue, under commercial production in Alaska and elsewhere, continues to be one of the more consistent performers in trials at Prudhoe Bay. Other red fescues also have shown promise while some have failed. Arctic material has been obtained of this species that performs adequately for seed production at Palmer. Selections have been made for varietal designation and seed increase is in progress. The arctic material has compared to Arctared in performance at Prudhoe Bay, though to date it has not appeared particularly superior. It is considered to have merit, however, because of its arctic origin. Further tests were established in 1975 involving Arctared and the arctic selections. Other red fescues are under study, but to justify serious consideration they must prove superior to Arctared. Red fescue is a medium height, fine-leaved grass.

Poa glauca - The grass that consistently has performed the best in trials at Prudhoe Bay, as was confirmed by results obtained in 1975, is some arctic material of Greenland bluegrass (Poa glauca). Other entries of this species have been unsatisfactory. Seed collections of the arctic material were originally made in 1969 and 1970 from populations found growing along the Sagavanirktok River. Individual selections were necessary among plants established in a spaced-plant nursery regarding fitness for seed production, as many proved unsatisfactory for this purpose. Plantings in 1973, 1974, and 1975 have tested the fitness of this selected material for use in the Arctic. Seed supplies have now been augmented of the selected material for distribution to commercial growers. This material will be registered as a named variety. Greenland bluegrass is a short growing, tufted grass that heads profusely.

Poa pratensis - Nugget Kentucky bluegrass (Poa pratensis) has had mediocre success in Prudhoe Bay plantings. It has sustained considerable winter injury or has been eliminated on the more exposed sites, while weathering satisfactorily on some sheltered sites. A number of bluegrasses from Scandinavia and north temperate locations have failed. Others collected in Alaska and of Icelandic origin that are under trial may have promise. Kentucky bluegrass is short to medium in height and has good spreading qualities under favorable conditions.

Puccinellia - Some native alkaligrasses (P. borealis, P. sp.) of western Alaska and northern interior origin have provided good cover in a variety of situations in 1972, 1973, and 1974 plantings at Prudhoe Bay. They grow as relatively tall, shallow rooted tufted plants. They mature rapidly and may have the possibility of producing seed under arctic conditions. Seed of this material is being increased.

Mixed Plantings

Some large block plantings of mixtures of the most promising grasses were established in 1974 and 1975. In previous small-plot plantings of mixtures involving Arctared with each and all four entries of Greenland bluegrass, hairgrass, Nugget bluegrass, and alkaligrass, the Greenland bluegrass has tended to dominate those plantings in which it was involved. Hairgrass and alkaligrass grow taller than the red fescue. Nugget bluegrass was the poorest performer. Plantings of mixtures with and without an annual (ryegrass) were conducted in early and late summer of 1975. The early summer planting did poorly. The late summer planting involving certain mixtures constitutes another test of the fall planting mode and of

the behavior of certain plant combinations. This planting included annual ryegrass as a component of some of the mixtures. Ryegrass has been successfully fall-seeded in other areas. Including an annual with perennials may be a means for providing a temporary cover in the first year while the perennials are getting established.

Relationships of Test Materials with Native Flora

Most of the plant materials that have come out of the tests with the best potential for use are of the same species as grasses that occur in the Prudhoe Bay (coastal plain) or mid to upper Sagavanirktok River (foot-hill) areas of the Arctic. These include Festuca rubra, Deschampsia caespitosa-beringensis, Poa glauca, Arctagrostis latifolia, and Calamagrostis canadensis. Others are related to species found in these areas, including Poa pratensis, related to Poa arctica, and Puccinellia borealis, related to P. langetana. Thus 5 of the species including promising materials are found in the region of proposed application while two of them are not.

Planting Failures and Treatments

Some of the failures in our research trials are of significance. Early summer seedings on the Winter Haul Road in 1974 essentially failed, even though the seedings were raked in and tamped. It was thought that they may improve and develop an adequate cover in 1975, but this did not happen. The failure was not owing to the use of unadapted materials, as these plantings included the better adapted selections.

Having sufficient moisture available when temperatures are appropriate for germination and establishment can be a serious limiting factor in the Arctic. Seed that lies on the surface or is provided with only a shallow

covering without packing is particularly vulnerable. It eventually may be dislodged by the wind and fed upon by birds. Bird predation of seed exposed on the surface appears to be a significant factor.

A large fall-planting trial was conducted in 1974 on a well-drained site for evaluation in 1975. Fall planting presumes to give the seed a chance to benefit from the moisture present in the soil at the beginning of the summer season. The trial employed different treatments, including thorough raking and tamping. Nevertheless, except for low spots in the plots, the trial was a failure. Some minor successes in low spots indicated moisture was a critical factor. A large number of birds were observed feeding on the plots after the seeding, so they, too, were a factor. Providing more cover for the seed with firm packing may improve the situation with regard to moisture and bird predation. This may be accomplished by deep scarifying with dragging and packing or by drilling the seed in furrows. Of course, adding water at appropriate times can alleviate the dryness. Seeding with a mulch, as in hydroseeding, can provide a more favorable environment for the seed. The difficulty of establishment is less on inherently moist sites that are not too wet.

When successful seedings have been established and good stands obtained, they generally have been fertilized at about 600 to 800 lb/acre of commercial mixes of 8-32-16 or 14-30-14, which supply 8, 32, and 16 or 14, 30, and 14 lbs of nitrogen (N), phosphate (P_2O_5), and potash (K_2O), respectively, per 100 lbs of fertilizer applied. Refertilization has benefitted growth and should be accomplished by the second year after seeding. This may be done at a reduced rate--300 to 500 lb/acre. The further need of fertilization and its effect is a matter still under study.

FERTILIZER AND NUTRIENT STUDIES

Experiments dealing with fertilizer needs have been conducted since 1972. Those figuring in evaluations in 1975 are listed in Table 1. A synopsis of results is given below.

1974 PKMg Perennial Seeding

This experiment was established to confirm with a perennial grass that phosphorus (P) and potassium (K) were limiting plant growth in the Prudhoe Bay soils. In 1972-1973, cereals were used as indicator plants in soil fertility tests to obtain more immediate results than unproven perennial grasses would provide. Since there are differences in nutrient requirements among grass species it was necessary to test the findings from the cereal-fertilizer trials on perennial grasses adapted to the Arctic environment.

In addition, magnesium (Mg) was believed to be the most likely micro-nutrient deficient in the soils, so it was included in this experiment. The entire area was seeded on September 24, 1975, with spring rye (70 lbs/acre). Fertilizer treatments were then applied to the seeded area.

Fertilizer treatments that included P were obviously important for establishing the perennial grass, (*Puccinellia*). According to visual evaluation of the 81 plots, the most significant response was due to P. Data were not precise enough to indicate a response to K, and there was only a hint that Mg fertilization may have reduced stand quality.

1974 NPKMg Perennial Seeding

This 16-plot series was included along the southern edge of the block of the PKMg plots on the scraped side, to test the need for nitrogen

TABLE 1. A listing of seven fertilizer experiments, dates established, location, and their representative purposes.

<u>Year Established</u>	<u>Experiment</u>	<u>Location</u>	<u>Purpose</u>
1972	A72 Plots	Winter Haul Road, Drill Site 2	Long-term fertilization effects
1974	PKMg Perennial Seeding	Scraped Site	Soil fertility evaluation
1974	NPKMg Perennial Seeding	Scraped Site	Soil fertility evaluation
1974	Oil Spill Seeding	ARCO topping plant	Oil spill rehabilitation
1975	Tundra Fertilization	Near Scraped Site	Effects on growth and plant composition
1975	Growth Chamber Evaluation of Prudhoe Bay Soil	Palmer	Requirements for N, P, K and micro-nutrients
1975	pH Effect on <u>Poa glauca</u>	Palmer	Tolerance of <u>Poa glauca</u> to acidic soils

fertilization, because our conclusions about the N availability were formerly based on data from the Winter Haul Road near Drill Site 2.

At the scraped site, P was the most significant fertilizer treatment in establishing Puccinellia seedlings. Without P, all other fertilizers were practically useless. A slight but impractical response to N alone was noted, but when P was added a significant response to N occurred. K alone was ineffective, but when combined with either P or N, K fertilization improved the Puccinellia stand, the most significant improvement being the PK combination.

Natural N levels in the soil at the scraped site was 25 ppm, about half that on the Winter Haul Road, which could have accounted for the inconsistent responses of N fertilization between the two areas.

1974 Oil Spill Seeding

These 16 plots were identical treatments to those of the 1974 NPKMg plots on the scraped site. The objective was to screen fertilizers for their effectiveness in establishing perennial grass on an oil-damaged site. The spill site near the ARCO topping plant was chosen for study because it was convenient, it represented an actual spill on tundra, and we already had data for that site. The oil was residual oil after processing in the topping plant.

Although this wet, highly organic tundra soil still contained oil, seedlings of Puccinellia germinated and grew in plots receiving P fertilization. Soil tests indicated natural N level in this soil was about 7 ppm, about 8 times lower than that on the Winter Haul Road, and 3.6 times lower than on the scraped site. We found no response to nitrogen in these plots. Since there was a relatively minor effect of N applications on the

soil test, it was possible that the natural organic matter and added oil carbon was so high that the added N in fertilizer was unavailable to the higher plants.

These are the only known oil spill plots in the Arctic U.S. in which there have been successfully established grasses by seeding and fertilization. Continuing to document the progress of these plots will be a highly significant venture.

A72 Perennial Seeding

This seeding, established on September 19, 1974, on plots that were fertilized on June 28, 1972, was designed to evaluate residual effects of fertilizers in these arctic soils, to establish a perennial grass in place of the annual cereals formerly grown on these plots, and to test effectiveness of these fertility levels on a perennial grass.

Spring rye and Puccinellia were over seeded and raked into plots in the fall of 1974. The most striking responses in establishment of the Puccinellia were again with P. K was the next most needed soil nutrient and N alone was apparently ineffective. P and K interacted to enhance stand establishment. Soil test results for samples collected September 5, 1975, confirmed that the effects of the 1972 fertilizer applications were still persistent in these soils.

Fertility Evaluation of Prudhoe Bay Soil

Soil was collected in the fall of 1974 from the scraped site at Prudhoe Bay. The soil was transferred to Palmer and stored in a moist condition. During the summer of 1975, the soil was added to 8-oz styro-foam cups along with various fertilizer amendments and seeded to barley.

Daytime temperature was maintained in a growth chamber at 12 C with a night temperature of 7 C.

Two studies were conducted under these conditions. The first study involved a N-P-K factorial design. Rates of fertilizer addition corresponded to 0, 100, and 200 lbs/acre for N and K; and 0, 200, and 400 lbs/acre for P. Early growth of the plants indicated K to be severely lacking. All plants in treatments not receiving K were showing deficiency symptoms in 2 1/2 weeks. Plants were harvested in 6 weeks and dry weight of the tops was determined.

The addition of each nutrient was evaluated by itself and in combination with other nutrients. The single addition of N or P did not increase yield; however, the addition of K by itself was definitely beneficial. When combinations of N, P, and K were included, each contributed to dry-weight production; for example, soil receiving the low rates of both P and K responded tremendously to N application. Thus highest yields were obtained when all three nutrients were added. Yield from soil receiving the highest fertilizer additions corresponded to approximately 3 times the yield when no fertilizer was applied.

A second growth-chamber study was designed to evaluate the requirement of micronutrients. The Prudhoe Bay soil was uniformly fertilized with 100 + 200 + 100 lbs/acre of N, P, and K respectively. Eleven treatments with three replications were included. Each micronutrient was individually added to the containers at specified rates. The rates of addition were chosen based on agronomic work in the lower 48. Additionally, three levels of the secondary nutrient magnesium were evaluated. These rates corresponded to 100, 200 and 300 lbs Mg/acre.

Statistical analysis at the conclusion of the study indicated none of the micronutrients had a significant effect on dry-weight production. The trend with increasing levels of Mg was to increase growth; however, this increase was not statistically significant.

After harvest of the R-P-K factorial and the micronutrient study, the treatment containers were removed from the growth chamber and placed in a greenhouse. The greenhouse utilized the natural lighting of late summer with temperatures varying from 15 to 25 C. Individual plants, which had been harvested at ground level, quickly resumed growth. A second harvest was made in 6 weeks. This evaluated the residual effect of added fertilizers under temperature conditions more conducive to rapid plant growth--and consequently rapid nutrient uptake. The more rapidly nutrients are removed from the soil, the greater the stress on the soil and applied fertilizer to provide those nutrients. Although the dry weight of tops has been determined, the data still awaits statistical analysis.

Fertilization of the Tundra

What changes can be expected in the native plant community of the tundra due to the addition of fertilizer? This study was designed to evaluate the effects of fertilization on 1) individual plant growth and 2) species composition due to specific nutrient additions.

The experimental plan consisted of 54 plots on the tundra with 3 replications of 18 treatments. Two levels each of N, P, K, and Mg were included in the factorial design; another treatment consisted of N, P, K, and Mg with and without added micronutrients. The micronutrients were added as fritted trace elements and included Fe, Mn, Cu, Zn, B and Mo.

Spring and fall fertilizings were made on 1 July 1975 and 9 September 1975. By the end of the first growing season, no visual effects due to fertilization were observed. However, it was noted that surface applied treble superphosphate under arctic conditions was very slow to dissolve.

Effect of pH on Growth of *Poa glauca*

A greenhouse study was initiated to determine 1) the most desirable soil pH and 2) the effect of adverse soil pH's on *Poa glauca* growth. *Poa glauca* is one of the more promising grasses being evaluated for revegetative work on the North Slope. Certain plant species are more sensitive to pH differences than are other species. With the tremendous variation in soil pH along the pipeline route (from pH 4 to pH 8), it was desirable to determine the pH tolerance of *Poa glauca*.

A soil mixture consisting of 1/2 silt loam and 1/2 Canadian peat (by volume) was used in the study. This hopefully reflected the organic nature of many of the soils along the pipeline route. Calcium hydroxide ($\text{Ca}[\text{OH}]_2$) was added at equivalent rates up to 27 tons/acre. The experiment was conducted using a completely randomized design with 4 replications.

Plants were harvested at 11 weeks and total dry weight of tops was determined. Analyses indicated maximum growth occurred at an approximate pH of 6, with growth at 5.6 and 6.2 being significantly higher at the 0.01 level than growth at all other pH's. Furthermore, the yield at pH 3.9 and 7.7 were essentially equal and only 1/3 reduced from the maximum yield obtained. This indicated *Poa glauca* is not severely affected by a rather wide range of soil pH's.

Nutrient uptake by plants and selected soil-chemical properties also were determined. With the highest yields, the percent N in the plants was

at a minimum suggesting this to be the nutrient preventing further growth. As lime additions increased, both the percent K and Mg decreased in the tops. Apparent trends did not exist between yield and the other nutrients analyzed.

NATURAL REHABILITATION AND DISTURBANCE EFFECTS

The purposes of these plots were to establish a base-line on certain plant communities that were likely to change over time, to monitor changes in naturally disturbed and revegetated plant communities and to document observations that generally fade from memory in time.

Transplants of native tundra - These were largely unsuccessful in spreading from their point of planting, and have provided no new ground cover except for Arctagrostis latifolia and a native Poa. These two grasses are apparently able to invade new territory. Arctagrostis is a species that increased in the old weasel trails on relatively dry sites in the Naval Petroleum 4. Incidentally, Arctophila fulva invaded the wet weasel trails behind HARL at Barrow.

Seeding establishment of native plants - On the Winter Haul Road, rather extensive stands of the native mustard, Braya, have become established. In the years 1974 and 1975 these stands became very prominent. With populations at levels now approaching maximum plant density in some locations, there may be some rather significant developments in secondary succession in the near future. There is no known study in the arctic United States in which secondary succession is being documented as in these locations at Prudhoe Bay. Since an understanding of secondary succession, i.e. recognizing stages, significant plant species and the

time frame requirements, is basic to vegetation management, results of this study are becoming increasingly valuable each year.

Recovery of native vegetation on scraped site - Rather remarkable growth and ground cover has developed on the scraped site where plants were not killed by tilling following the scraping operation. Fertilization has enhanced that recovery by stimulating vascular plant growth and permitting mosses to reestablish themselves. Without fertilization there has been essentially no recovery of the moss layer removed during scraping.

Thermokarst - Significant heaving and subsidence has occurred on the scraped site during the 1972-1975 period. The eventual results of these ground actions are unpredictable, but visually they seem to be exaggerations of the natural landscapes.

Pond migrations - Arctic ponds migrate across the landscape, capturing watersheds from each other. In one photo-plot, we have measured the movement of a rather small, shallow arctic pond which has moved about 1 inch per year during the study period, 1972-1975. Permanent developments near the cutting edges of arctic ponds and lakes should be rip-rapped in order to control such erosion processes.

FUTURE WORK

Because of the difficulties encountered in establishing plants on well drained, potentially dry sites, further tests will be conducted on seeding procedures.

A trial will be established on a dry site testing different planting depths with packing. This will involve surface raking, deeper raking, and planting in furrows.

Another procedure also is being investigated. We have corresponded with a commercial seed-coating firm that reports some success in promoting better germination and establishment under adverse conditions using their seed-coating methods. Assuming satisfactory arrangements can be made with this firm, we will have samples of our seeds coated for testing under arctic conditions.

Further tests will be conducted of mixtures of the better suited grasses. These have not been tested in all combinations. One study will be conducted to test combinations of grasses under grazing pressure. Plots will be established in an area where ground squirrels are prevalent. The effect of combining grasses with possible differences in palatability will be studied. Possibly, in such a combination, the more desirable grasses may absorb the grazing pressure, thus permitting better establishment of the less desirable grasses. At any rate grazing pressure is one of the factors these grasses must contend with.

A test planting of a number of annuals will be established. This will include both cereals and a number of varieties of annual ryegrass. The poor showing of an annual ryegrass used in some 1975 plantings prompted this study, plus consideration of the possible need for establishing a better temporary cover than can be done with perennials.

Other studies will be instituted applying findings from the nutrient and fertility studies that have been in progress.

Also, if a suitable area is made available, trial plantings of different grasses will be established to test their adaptability for turf development in the Arctic. It is possible that fescues and bluegrasses could develop an aesthetically pleasing turf, even under arctic conditions,

if given sufficient attention. Some thought may be given to the development of a putting green, if there is such a desire.

Observations will continue on the natural rehabilitation and the effects of disturbances.

Comparisons, selections, and seed increase will continue as a major operation at Palmer.

